Non-Destructive Evaluation of Large Aperture Optics with Ultra-Low Optical Absorption

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The Laser Interferometer Gravitational Observatory (LIGO) project, scheduled for initial operation in 2000, aims to detect and study gravitational waves from astrophysical sources by precision interferometry between suspended test bodies over a four-kilometer baseline. The required sensitivity places extreme demands on the performance of optical systems, especially optical components. For example, certain LIGO optics require very stringent limits to the fraction of impinging laser light which is absorbed either in coating (a few ppm) or in bulk substrates (<10 ppm). Further improvements in LIGO will require even lower absorption (sub-ppm). In addition to the ultra-low absorption, LIGO optics are also large aperture components, with a standard diameter of 25 cm and thickness of 10 cm. Characterization of absorption at sub-ppm level for such a large component presents a special challenge. The project outlined in this talk is an effort to explore technical approaches for performing high quality nondestructive evaluation of large aperture optics with ultra-low optical absorption. It seeks to support advances in state-of-the-art interferometric gravity wave detection by developing photothermal capabilities for measuring absorption and related effects in advanced optical materials and coatings. More specifically, we will discuss about the development of an ultra-sensitive detection system for weak absorption studies of both thin film coatings and bulk substrate materials, using a laser-induced optical diffraction phenomena. Discussions will also be presented for using the same diffraction effects to develop novel sensing techniques for other applications, including spectroscopic photothermal microscopy for studying localized defects and impurities of the optics for high power laser applications.